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MODIS thermal emissive bands calibration uncertainty analysis

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ABSTRACT

A key instrument for the NASA EOS mission, the Moderate Resolution Imaging Spectroradiometer (MODIS) is currently operating on-board the Terra and Aqua spacecrafts. The MODIS has 16 Thermal Emissive Bands (TEB), with each having 10 detectors, covering the wavelengths from 3.7 to 14.4 μm . On-orbit each detector is calibrated by an on-board calibrator (OBC) blackbody (BB). Except for the low gain band used for fire detection, the thermal emissive bands use a quadratic algorithm in the Level 1B (L1B) code for calibration and for retrieval of top of the atmosphere (TOA) scene radiance. The specified calibration uncertainty of 1% applies to most of the TEB at their typical scene radiance levels and for scene-viewing angles inside a $\pm 45^\circ$ range (relative to instrument nadir). The requirements for two Sea Surface Temperature (SST) bands at 11 μm and 12 μm and for a low gain fire band are 0.5% and 10% respectively. The uncertainty requirements are twice as large at other non-typical radiance levels or at viewing angles outside the $\pm 45^\circ$ range. This paper reviews the MODIS TEB calibration algorithms and presents the calibration uncertainty analysis, including the methodology and results. Discussions will be focused on the key contributors to the uncertainty computation in the L1B. Results of the estimated uncertainties with the specifications at typical radiance level and at instrument nadir will be provided. A separate paper in this proceeding gives similar analysis for the MODIS Reflective Solar Bands (RSB).

Keywords: MODIS, Terra, Aqua, TEB, thermal emissive, infrared, uncertainty, blackbody, calibration

1. INTRODUCTION AND INSTRUMENT BACKGROUND

The MODerate Resolution Imaging Spectroradiometer (MODIS), a key instrument for the NASA's Earth Observing System (EOS), is currently operating on both Terra and Aqua spacecrafts¹⁻³. The MODIS ProtoFlight Model (PFM) onboard the Terra spacecraft (EOS AM) was launched on December 18, 1999. The instrument nadir aperture door was opened on February 24, 2000 for data acquisition. This marked the beginning of a series of unprecedented long-term global science data records from MODIS observations. About two and half years later, MODIS Flight Model 1 (FM1) was launched on May 4, 2002 onboard the Aqua (EOS PM) spacecraft. Aqua MODIS science data acquisition started after nadir door opened on June 24, 2002. It further enhanced and extended the existing Terra MODIS science data products. Both Terra and Aqua satellites are operated in near sun-synchronous polar orbits with a nominal orbit altitude of 705 km. Terra's orbit passes from north to south across the equator in the morning at 10:30 AM local time, while Aqua passes south to north over the equator in the afternoon at 1:30 PM local time. These orbit designs allow the two MODIS instruments to make measurements over the same Earth scene with morning and afternoon observations respectively. Both Terra and Aqua MODIS are able to provide complete global coverage in less than 2 days, enabling short- and long-term studies of the Earth's land, oceans, and atmosphere. Currently both MODIS instruments are performing well on-orbit. Together they have acquired over 6 years of Earth Science observations.

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